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Car Hood Space Temperature Condition Management

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Abstract

With the intent to improve the efficiency of car operation, we offer to manage the value of the cross-section of the grille. It allows achieving the reduction of the pollutant emissions of exhaust gases during the preparation period to operate the engine when warming it up at idle and also decreasing the engine warm-up time and increasing the time of cooling.

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Keywords: Temperature condition; hood space; engine; warm-up time

1. General information

Nomenclature	
Qhood space in	the amount of heat generated to the hood space, J/s
Qe	heat equal to the effective engine work per 1 s, J/s
Qexh.gas	heat lost together with exhaust gases, J/s
Qcoolant	heat transferred to the cooling medium, J/s
Qinc.com.	heat lost due to chemical incomplete combustion of the fuel, J/s
Qunac.los.	unaccounted heat losses, J/s
ki	ratios accounting the heat portion of the relevant component transferred to the hood space
S	total square of the radiator grill, m2

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S1	square of the upper radiator grill, m2
S2	square of the lower radiator grill, m2

To operate cars at low environmental temperatures one ought to follow some supplementary specifications. Before car use the engine should be prepared for loading. The preparation time to operate the car consists of [1]:

- time of warming preparation of the engine with additional devices;
- the engine warm up time at idle.

Warming the engine up at idle is necessary to increase the temperature of its parts and systems with intent to reduce its negative impact on the life of the engine.

The value of the temperature impact on the life of the engine components and parts depends on:

- value of the actual temperature pattern departure from the recommended one;
- rate of change and the frequency of drops of the actual temperature pattern;
- material they are made of.

For example, the rate of the engine wear and tear when the coolant temperature is 20ºC increases more than in 3.5 times, and when the temperature is 40ºC – more than in 1.5 times [2-6]. Not only decreasing of the temperature condition but also its increasing influences the life of the engine (Fig. 1).

So, if the temperature is high some engine parts could be deformed and some engine systems could operate defectively. This fact can reduce the life of the engine. That is why it is necessary that the temperature of the internal combustion engine should be varied within constant, relatively narrow range and the coolant temperature should be 95ºC (for engines of VAZ 2112).

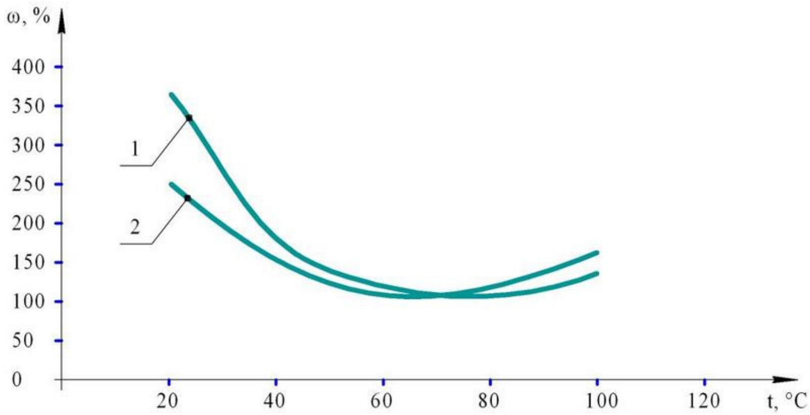

Fig. 1 Schedule of Wear on Relative Rate Changes for Diesel and Gasoline Engines (ω) Depending on Coolant Temperature (according to NAMI information): 1 – gasoline engine; 2 – Diesel engine

The engine warm up time depends on some design and operational factors. The environmental temperature plays the major role. During the winter period the negative influence of low temperatures is decreased by insulation under the hood. The insulation stores heat inside the hood space. At the same time the hood space contacts with the environment via gaps between the body parts, the radiator grill and the holes in the engine protection. Thanks to the process some heat is transferred to the environment [7-9].

The temperature change of the engine accessory and hood space nodes depends on:

- change of the accessory internal temperature;
- change of the neighbor accessory temperature;
- number, temperature and stream of the air washing the accessory[10];
- design accessory components.

The internal temperature of the accessory decreases mainly thanks to their work. The key sources and reasons of different heat recession inside the accessory, nodes and equipment in the hood space are:

- temperature generated during fuel combustion in the compression chambers;
- temperature generated due to operation of friction nodes;
- temperature generated due to operation of devices of electrical, hydraulic and pneumatic equipment.

One of the important problems of the warm up period is accumulation of the heat generated to the hood space, the other problem of the period of steady temperature condition in the engine is its operating temperature maintenance; and one more problem of the engine overheating period is effective heat dissipation [11, 12].

2. Theoretical part

Heating engine condition plays the major role in the thermal mode of the hood space. Temperature conditions of the hood space should maintain the steady temperature mode in the internal combustion engine and also nodes and hood space accessory. The thermal mode of the hood space should change depending on the engine temperature condition. The temperature condition of the hood space can be presented as a thermal balance of the internal combustion engine taking into account some additional factors.

At the steady- state temperature of the engine operation the heat amount produced to the hood space $Q_{\text{hood space in}}$ should be equal to the heat amount transfered from the hood space $Q_{\text{hood space out}}$, that is

$$Q_{\text{hood space in}} = Q_{\text{hood space out}} \quad (1)$$

The amount of heat generated to the hood space can be presented as a function

$$Q_{\text{hood space in}} = f\left(Q_e, Q_{\text{exh.gas}}, Q_{\text{coolant}}, Q_{\text{inc.com.}}, Q_{\text{unac.los.}}\right) \quad (2)$$

Only a portion of heat is transferred to the hood space that is accounted by relevant equity ratios. The amount of heat generated to the hood space with account of the equation if the external thermal balance of the internal combustion engine [13]

$$Q_{\text{hood space in}} = k_e Q_e + k_{\text{exh.gas}} Q_{\text{exh.gas}} + k_{\text{coolant}} Q_{\text{coolant}} + k_{\text{inc.com.}} Q_{\text{inc.com.}} + k_{\text{unac.los.}} Q_{\text{unac.los.}} \quad (3)$$

The heat source in the hood space is the engine systems namely cooling systems and systems of exhaust gases emission (Fig. 2).

In general the heat transferred to the hood space should be accumulated till the engine starts its operation at the steady temperature condition. After achieving the steady temperature condition the excess heat is informed to the environment.

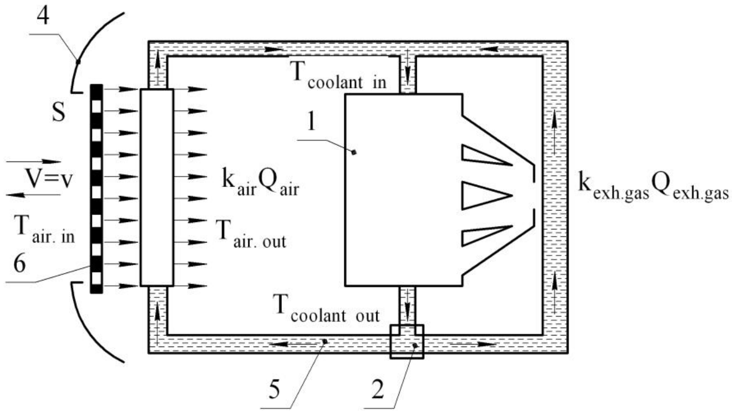

Fig. 2 Hood Space Thermal Balance Scheme: 1 – internal combustion engine, 2 – thermostat, 3 – radiator of cooling system, 4 – the front of the car, 5 – branch pipes of cooling system, 6 – managed insulation

The amount of heat given by the cooling system to the hood space directly depends on the air volume streamed through the radiator; therefore to define the ratio kв the next formula can be used

$$k_e = (SS_1)/S \tag{4}$$

or

$$k_e = S_2 S^{1} \tag{5}$$

where $S = S_1 + S_2$ – total square of the radiator grill, m^2;
S_1 – square of the upper radiator grill, m^2;
S_2 – square of the lower radiator grill, m^2.

Ratio $k_{\text{в}}$ takes into account the heat change in the hood space due to heat emission of the engine cooling system and absorption of heat from the environment. So for the cars VAZ 21120 the ratio $k_{\text{в}}$ can be varied from 0,49 till 1,0, i.e. from 49% till 100% of heat generated by the cooling system can transferred to the hood space. At that S_1 should possible be changed.

3. Practical realization

The value of the grill section area should be managed according to the order shown on the Fig. 3. To perform the management function the car is necessary to be equipped by some additional device. The facility can be placed during the regular maintenance.

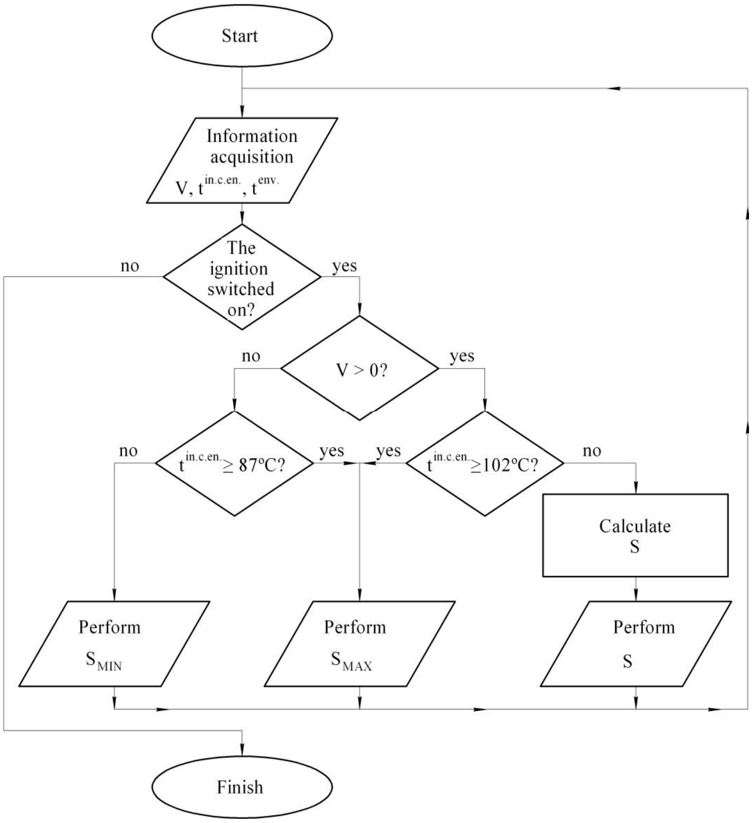

Fig. 3 Operation Order of Facility to manage Heat Change between Hood Space and Environment (ICE - Internal Combustion Engine)

If the car speed V is 0 km/h and the engine works within the unsteady temperature condition (the coolant temperature is less than 87 ºC (for the engine of VAZ 21124)) it is necessary to close the valve completely, and if the engine has already accumulated the required heat amount (the coolant temperature is 87 ºC or more) the valve is necessary to be opened fully. In this case the efficiency of heat abstraction from the cooling system radiator is low as the air heated by the radiator is not abstracted out of it.

If the speed $V \geq 0$ km/h and the thermostatic valve is closed fully (the coolant temperature is 102 ºC or more) it is necessary to provide more efficient heat abstraction from the cooling system radiator (let the air freely streaming to the hood space). If the coolant temperature is less than 102ºC and 87 ºC or more it is necessary to determine the requested square S [14].

4. The empirical results (findings)

According to the results of the performed experimental research [15] there has been established that when managing the temperature condition of the hood space during car use it is possible to achieve reduction of emissions of harmful substances by 4.9% after warming it up at idle due to decrease of preparation time to full car load. Warm-up time of the engine has been reduced by 5.3% and cooling time (if the engine is out of operation) has been increased by 20.3%.

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